
XX. Introductory Physics, Grades 9/10

Grades 9/10 Introductory Physics Test

The spring 2006 Grades 9/10 MCAS Introductory Physics Test was based on learning standards in the Physics content strand of the Massachusetts *Science and Technology/Engineering Curriculum Framework* (2001). These learning standards appear on pages 68–70 of the *Framework*.

The *Science and Technology/Engineering Curriculum Framework* is available on the Department Web site at www.doe.mass.edu/frameworks/scitech/2001/0501.pdf.

The reporting of results of the Grades 9/10 Introductory Physics Test is limited to *Test Item Analysis Reports*. No scaled score or performance level results are available.

Test Sessions

The MCAS Grades 9/10 Introductory Physics Test contained two separate test sessions. Each session included multiple-choice and open-response questions.

Reference Materials and Tools

Each student taking the Grades 9/10 Introductory Physics Test was provided with a *Physics Formula Sheet*. A copy of this reference sheet follows the final question in this chapter.

Each student also had sole access to a calculator with at least four functions and a square root key.

The use of bilingual word-to-word dictionaries was allowed for limited English proficient students only, during both test sessions. No other reference tools or materials were allowed.

Cross-Reference Information

The table at the conclusion of this chapter indicates the *Framework* learning standard that each item assesses. The correct answers for multiple-choice questions are also displayed in the table.

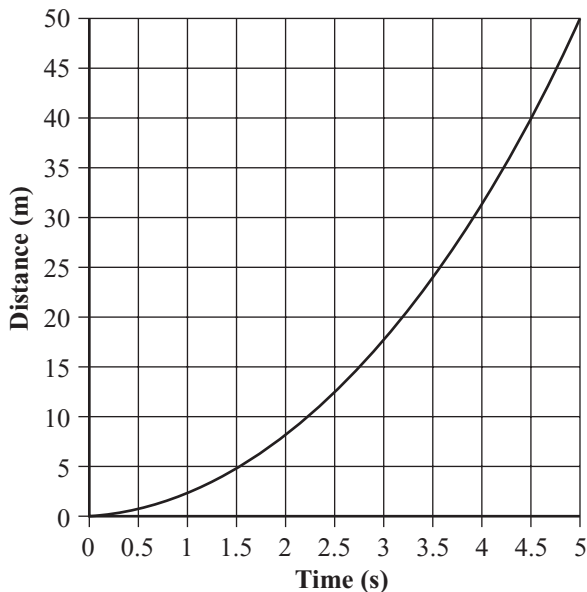
Introductory Physics

SESSION 1

DIRECTIONS

This session contains twenty-three multiple-choice questions and three open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

- 1 The distance vs. time graph below shows data collected as a remote-controlled car moved across a level parking lot.



According to the graph, which of the following conclusions about the car's motion is supported?

- A. The car is accelerating.
- B. The car is stopping and starting.
- C. The car is traveling at a constant velocity.
- D. The car is moving through an obstacle course.

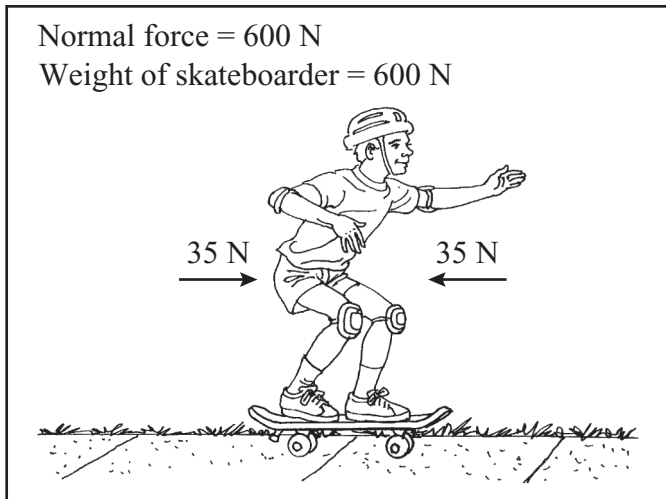
- 2 The figure below shows the regions of the electromagnetic spectrum.

Radio Microwave Infrared Visible Ultraviolet X-ray *Gamma Ray*

Which of the following statements **best** compares the wavelengths of the regions of the electromagnetic spectrum?

- A. Microwaves are shorter than x-rays.
- B. Infrared waves are longer than gamma rays.
- C. Radio waves are shorter than visible light waves.
- D. Ultraviolet waves are longer than visible light waves.

- 3 The forces acting on a skateboarder moving at a constant velocity along a sidewalk are shown in the figure below.



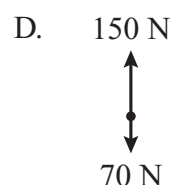
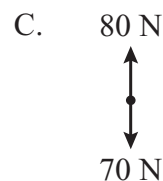
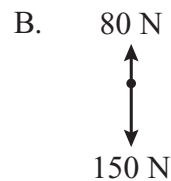
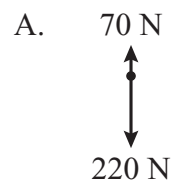
Which of the following is the net force on the skateboarder?

- A. 0 N
B. 70 N
C. 670 N
D. 1270 N
- 4 The tendency of a stationary object to resist being put into motion is known as
- A. acceleration.
B. inertia.
C. weight.
D. velocity.

- 5 In a copper wire, a temperature increase is the result of which of the following?

- A. an increase in the size of the copper particles
B. a decrease in the mass of the copper particles
C. an increase in the motion of the copper particles
D. a decrease in the distance between the copper particles

- 6 An upward force of 150 N is applied to a box weighing 70 N. Which of the following is the free-body force diagram for this situation?



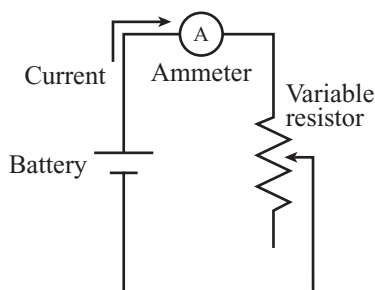
- 7 The masses and specific heats of some samples of liquids are shown in the table below.

Samples	Mass (kg)	Specific Heat Capacity (J/kg • K)
water	0.750	4200
glycerin	0.750	2400
methanol	0.750	2500
cooking oil	0.750	2100

The temperature of which sample will rise **most** when 1000 J of heat is added?

- A. water
- B. glycerin
- C. methanol
- D. cooking oil

- 8 An electric circuit is shown below. The accompanying table shows the current measured at different levels of resistance.



Resistance (Ω)	Current (A)
0.10	15.0
0.50	3.0
2.5	0.60
10.0	0.15

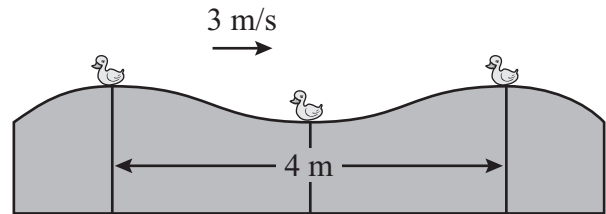
Based on the data shown in the table, what is the voltage drop across the variable resistor?

- A. 1.5 V
- B. 6 V
- C. 9 V
- D. 12 V

- 9 A sailboat travels 35 km in 5 hr. Which of the following describes the motion of the sailboat?

A. Its momentum is 7 km/hr.
B. Its acceleration is 7 km/hr.
C. Its displacement is 7 km/hr.
D. Its average speed is 7 km/hr.

- 10 The illustration below shows three toy ducks floating on water, moving up and down as a wave travels to the right with a velocity of 3 m/s.



Which of the following is the frequency of the wave?

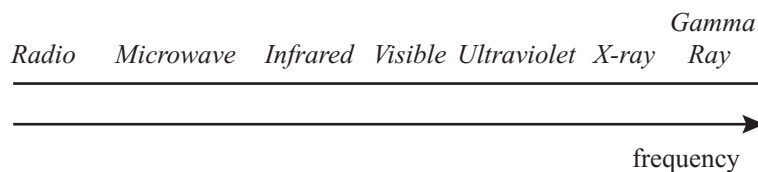
A. 0.75 Hz
B. 1.33 Hz
C. 1.5 Hz
D. 6.0 Hz

Question 11 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 11 in the space provided in your Student Answer Booklet.

- 11** The electromagnetic spectrum is shown below.



There are multiple stages involved in the transmission, reception, and display of a television broadcast. A signal is sent by satellite from the station and relayed to the television by several methods. The signal is translated electronically and converted into an image on regular, liquid crystal, or plasma TV displays. The viewer then sees the image.

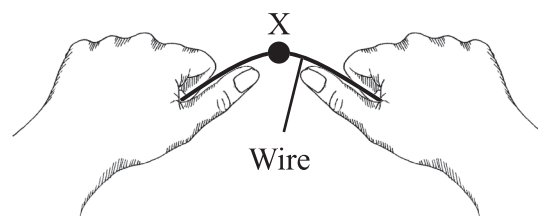
- Identify **one** region of the electromagnetic spectrum used by television and explain how it is used.
- Select a different portion of the electromagnetic spectrum that is **not** used by television. Explain a useful application of this spectral region.

Mark your answers to multiple-choice questions 12 through 24 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

- 12 Why does a plastic rod have a negative charge after being rubbed with a piece of fur?
- A. The fur gives up protons to the rod.
 - B. The rod gives up electrons to the air.
 - C. The fur gains protons from the rod.
 - D. The rod gains electrons from the fur.

- 13 Which of the following colors of visible light has the longest wavelength?
- A. red
 - B. blue
 - C. green
 - D. orange

- 14 The illustration below shows a student bending a piece of wire back and forth at a single point X. The wire's temperature rises noticeably at point X.







Which of the following **best** describes the source of the temperature increase?

- A. Some of the wire's mass is transformed into heat energy as the wire is bent.
- B. Some of the kinetic energy is transformed into heat as the wire is bent.
- C. The bending transfers potential energy to the wire, heating it.
- D. The bending causes a current that heats the wire.

- 15 Perfume sprayed from a bottle spreads more easily in a warm room of 25°C than in a cool room of 15°C . Which of the following correctly compares perfume molecules at 25°C to those at 15°C ?

A. At 25°C , they have more mass.
B. At 25°C , they are moving faster.
C. At 25°C , they have less kinetic energy.
D. At 25°C , they are decreasing in volume.

- 16 The diagram below represents four empty copper containers at room temperature.

1	2	3	4
			
100 g 20°C	200 g 20°C	400 g 20°C	800 g 20°C

An equal amount of water at 90°C is added to each copper container. Assume there is no loss of heat to the environment.

Which container will have had the **greatest** change in temperature when the water and the container reach equilibrium?

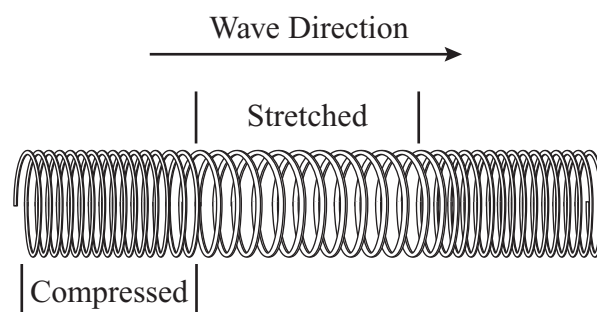
A. 1
B. 2
C. 3
D. 4

- 17 Two students each carry a box up to the third floor of a building. The total mass of each student and the box she is carrying is the same. Roberta makes the trip in 45 s while Mary takes 30 s.

Which of the following statements best describes this task?

A. Roberta does more total work than Mary.
B. Mary does more total work than Roberta.
C. Roberta has a greater power output than Mary.
D. Mary has a greater power output than Roberta.

- 18 The figure below shows a spring with a wave traveling through it.



Which type of wave is illustrated?

A. sound
B. transverse
C. longitudinal
D. electromagnetic

- 19 Which of the following devices relies on electromagnetic radiation in the radio wave region of the spectrum for operation?

A. sun tanning lamp
B. electric light bulb
C. cellular telephone
D. electric toaster

- 20 Which of the following has the **least** momentum?

A. a 0.5 kg mass with a 1000 m/s velocity
B. a 1 kg mass with a 100 m/s velocity
C. a 10 kg mass with an 11 m/s velocity
D. a 100 kg mass with a 2 m/s velocity

- 21 Mr. Jenkins constructed a circuit consisting of a variable source, wires, and a resistor. In order to triple the amount of current, how should he change the voltage of the source?

A. make the voltage three times larger
B. make the voltage one-third as great
C. make the voltage nine times larger
D. make the voltage one-ninth as great

- 22 One 7.0 kg bowling ball is lifted to a storage shelf 1.0 m above the floor. A second 7.0 kg ball is lifted to a storage shelf 2.0 m above the floor.

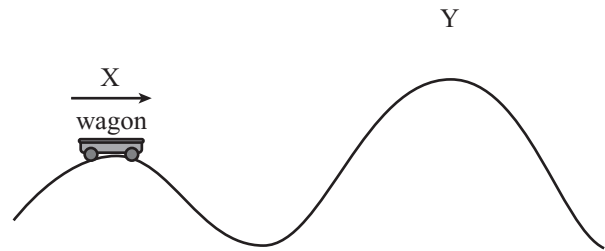
Which of the following **best** explains why the measured force of gravity on each ball is nearly identical?

A. The final potential energy of each ball increased.
B. The amount of work required to lift each ball is identical.
C. The distance of each ball from Earth's center of mass is almost identical.
D. The gravitational force of each ball on the other cancels out the force of Earth's gravity.

- 23 The water contained in a geyser system gains energy from the underground material surrounding it. The water molecules gain kinetic energy and this results in an increase in the pressure of the water. Eventually the geyser erupts and expels water into the air above ground. Which of the following types of energy is the source for the initial energy gain of the water?

A. electrical
B. magnetic
C. mechanical
D. thermal

- 24 The figure below shows a wagon that moves from point X to point Y.



Which of the following **best** describes the wagon's change in energy as it coasts from point X to point Y?

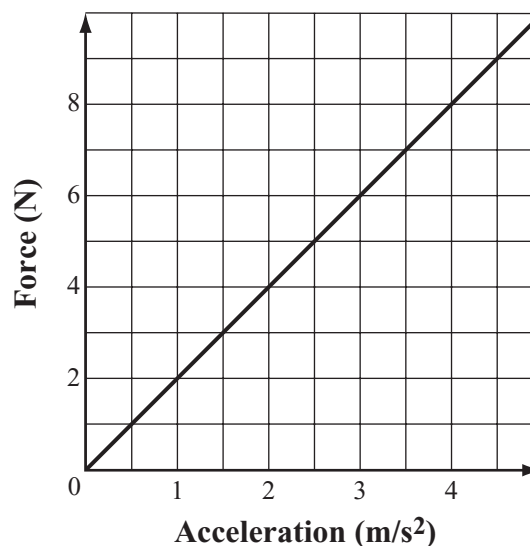
- A. The wagon has the same kinetic energy at point Y and at point X.
B. The wagon has more kinetic energy at point Y than at point X.
C. The wagon has the same gravitational potential energy at point Y and at point X.
D. The wagon has more gravitational potential energy at point Y than at point X.

Questions 25 and 26 are open-response questions.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF EACH QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 25 in the space provided in your Student Answer Booklet.

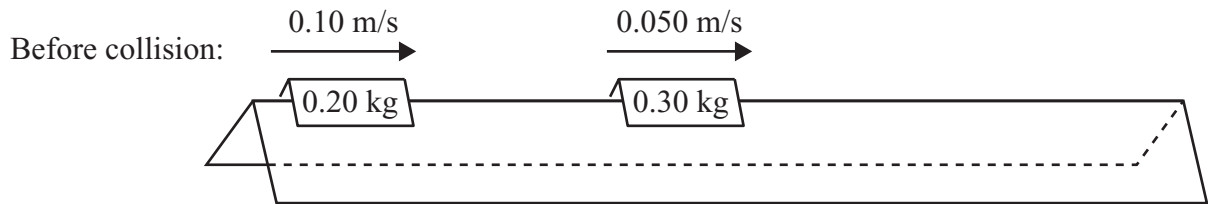
- 25** The figure below is a graph of net force vs. the acceleration of an object.



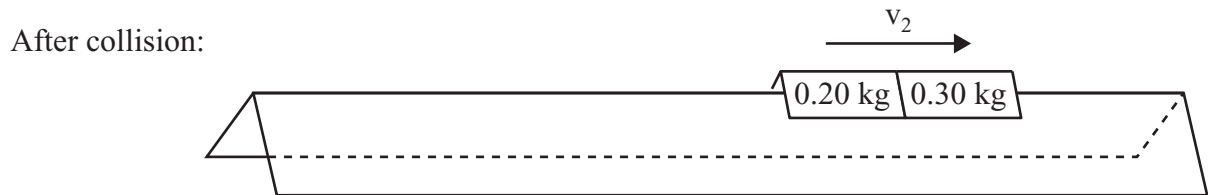
- Use the graph to determine the mass of the object. Show your calculations and include units in your answer.
- What acceleration will the object have if the net force is 50 N and the trend shown by the graph continues? Show your calculations and include units in your answer.
- On the grid in your Student Answer Booklet, draw a graph of force vs. acceleration if the mass of the object is halved and the object is subjected to the same net forces. Label the axes on your graph and be sure to include units. Label this graph “c.”
- On the same axes that you used in part (c), draw a graph of force vs. acceleration if the mass of the object is doubled and the object is subjected to the same net forces. Label this graph “d.”

Write your answer to question 26 in the space provided in your Student Answer Booklet.

- 26 The illustrations below show an air track with two carts before and after a collision. The mass and the initial velocity of each cart are shown below.



The first cart slides on the air track and collides with the second cart. The two carts stick together upon impact and move together along the track, as shown below.



- What is the momentum of the first cart before it collides with the second cart? Show your calculations and include units in your answer.
- What is the momentum of the second cart before the collision? Show your calculations and include units in your answer.
- Describe **two** changes that could be made initially to either one or both carts that would result in an increase in the momentum of the combined carts after the collision.

Introductory Physics

SESSION 2

DIRECTIONS

This session contains seventeen multiple-choice questions and two open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

- 27 Visible light passes through glass. Other types of electromagnetic radiation are able to pass through other materials in a similar way.

Which of the following are used in medical technology because they can pass through some parts of the human body?

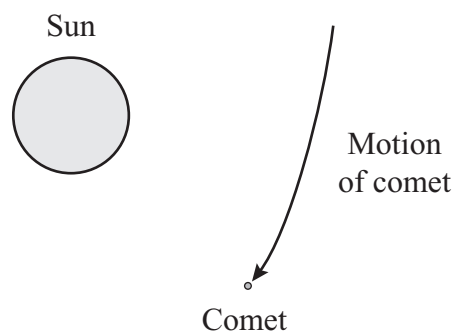
- A. x-rays
- B. infrared waves
- C. microwaves
- D. ultraviolet rays

- 28 A negatively charged rubber rod was brought near some small pieces of paper. The rod's charges repelled the negative charges in the pieces.

Which of the following caused the repulsion of the negative charges?

- A. conduction
- B. gravitation
- C. induction
- D. insulation

- 29 The Sun's gravitational attraction causes a comet's path to curve as shown in the illustration below.



Which of the following statements **best** explains the fact that the Sun does not appear to move due to the comet's gravitational attraction?

- A. The Sun's mass is much greater than the comet's mass.
- B. The comet is too far away for its gravity to affect the Sun.
- C. In this gravitational interaction only the comet exerts a pull on the Sun.
- D. The path of the comet reduces the Sun's gravity.

30 Which of the following changes occurs as a solid is heated?

- A. The kinetic energy of the solid decreases.
- B. The average density of the solid increases.
- C. The specific heat capacity of the solid decreases.
- D. The average molecular speed in the solid increases.

31 Which of the following describes the mechanical energy of a cart at rest at the top of a steep hill?

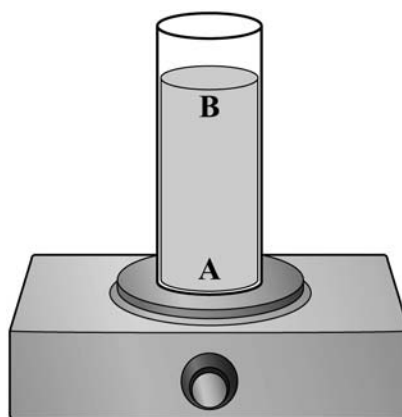
- A. The cart has no mechanical energy.
- B. The cart's mechanical energy is all kinetic.
- C. The cart's mechanical energy is all potential.
- D. The cart's mechanical energy is half potential and half kinetic.

Question 32 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 32 in the space provided in your Student Answer Booklet.

- 32** The illustration below shows a container of water on an electric hot plate. Point A is in the water close to the hot plate, and point B is in the water near the top of the container.



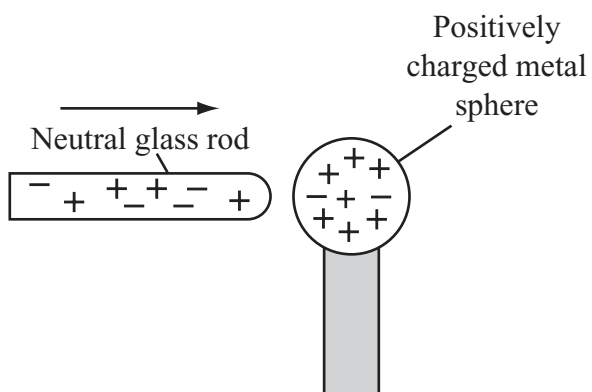
Electric hot plate

The water in the container is at room temperature before the hot plate is turned on.

- Describe the differences in the average motion of the water molecules at point A and at point B shortly after the hot plate is turned on.
- The water is heated until a thermometer placed in the center of the container reaches 100°C . Compare the average motion of the water molecules at points A and B at this temperature and explain your answer.
- The hot plate is then turned off. Describe the average motion of the molecules at points A and B after several hours.

Mark your answers to multiple-choice questions 33 through 38 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

- 33 The figure below shows a neutral glass rod and a positively charged metal sphere.



Which of the following **best** describes the movement of charges as this glass rod touches the sphere?

- A. Negative charges move from the sphere to the glass rod.
- B. Negative charges move from the glass rod to the sphere.
- C. Positive charges move from the sphere to the glass rod.
- D. Positive charges move from the glass rod to the sphere.

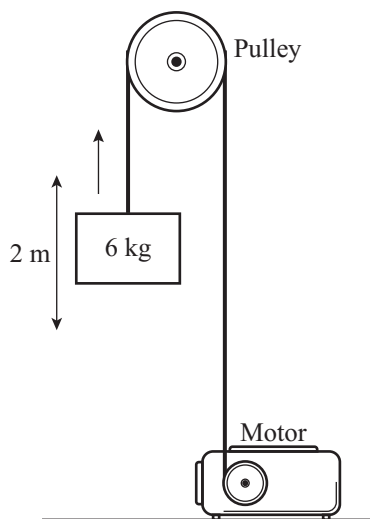
- 34 What is the voltage in a circuit with a current of 3 A and a total resistance of $12\ \Omega$?

- A. 0.25 V
- B. 4 V
- C. 15 V
- D. 36 V

- 35 What is the frequency of ocean waves that have a speed of 18 m/s and a wavelength of 50 m?

- A. 0.18 Hz
- B. 0.36 Hz
- C. 2.8 Hz
- D. 9.0 Hz

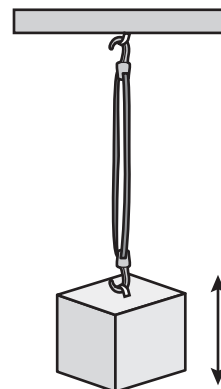
- 36 The diagram shows a motor being used to lift a load with the use of a pulley.



The motor is lifting the 6 kg box at a constant velocity. How much work is done on the box to lift it 2 m? (Assume no resistance from the pulley.)

- A. 3 J
- B. 4 J
- C. 60 J
- D. 120 J

- 37 The diagram below represents a mass suspended vertically by a rubber band. The mass is set in motion by pulling down slightly on the mass and letting go.



Which of the following correctly identifies the up-and-down motion of the mass?

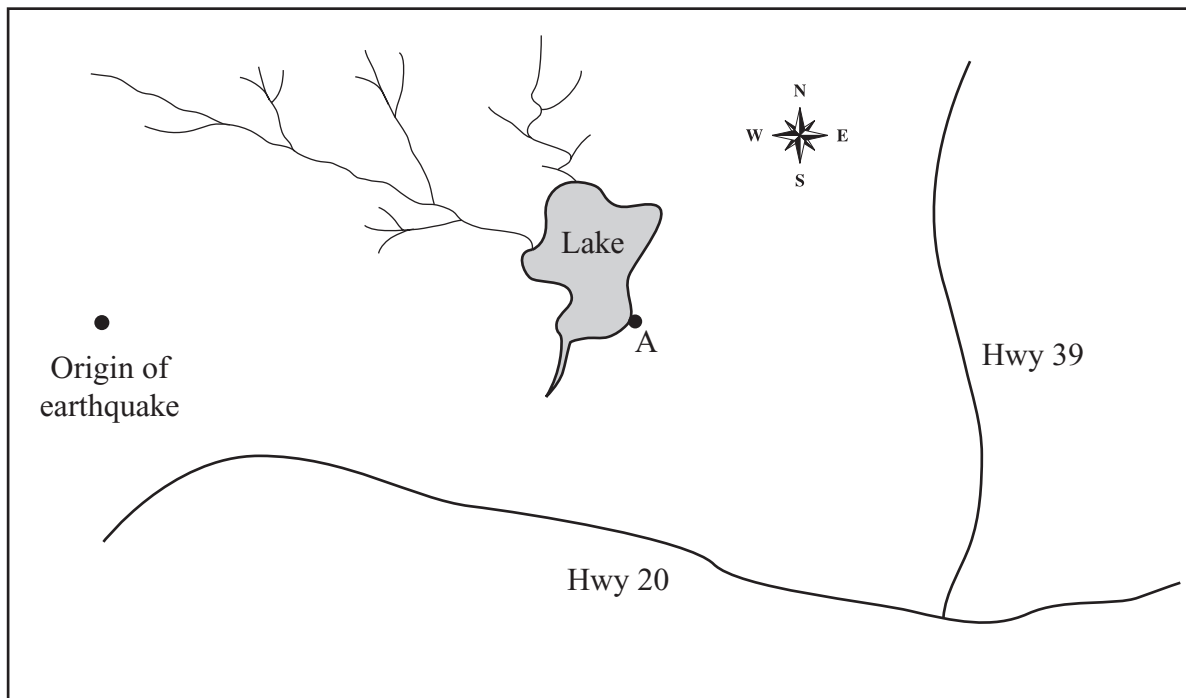
- A. torsional
 - B. transverse
 - C. nonharmonic
 - D. simple harmonic
- 38 Which of the following **must** be included with magnitude to represent a vector?
- A. mass
 - B. direction
 - C. acceleration
 - D. volume

Question 39 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 39 in the space provided in your Student Answer Booklet.

- 39** The map below represents the area near the origin of an earthquake.



Earthquakes generate several different kinds of waves. Longitudinal waves are called “P” waves, and transverse waves are called “S” waves. The “P” waves have a greater velocity than the “S” waves. An earthquake occurs and these waves travel to point A.

- Which type of wave is first to reach point A?
- Describe the expected movement of the ground due to the “P” waves and explain your reasoning.
- Describe the expected movement of the ground when the “S” waves reach point A, and explain your reasoning.

Mark your answers to multiple-choice questions 40 through 45 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

- 40 The instructions below outline the procedure for a demonstration.

Materials: four 100 g metal blocks, each of a different metal
four polystyrene foam cups, each containing 150 g of 10°C water

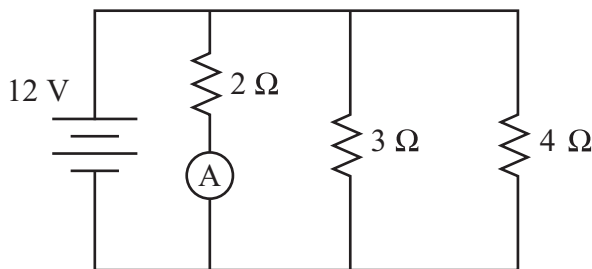
Procedure:

1. Place the four cups of water next to each other on the lab bench.
2. Heat each block to a temperature of 60°C .
3. Place each heated block in a separate cup of 10°C water.
4. Measure the temperature change in each cup of water after 100 s.

At the end of the demonstration, which block raised the temperature of the 10°C water the **greatest** amount?

- A. the block with the greatest density
- B. the block with the lowest surface area
- C. the block with the greatest specific heat
- D. the block with the lowest thermal conductivity

- 41 The circuit diagram below shows three resistors, an ammeter, and a battery.



How much current flows through the ammeter?

- A. 1.0 A
- B. 6.0 A
- C. 13.0 A
- D. 24.0 A

- 42 Some campers are sitting around a campfire outside their tent.

Which product of the fire is in the form of electromagnetic waves?

- A. light
- B. smoke
- C. sound
- D. water vapor

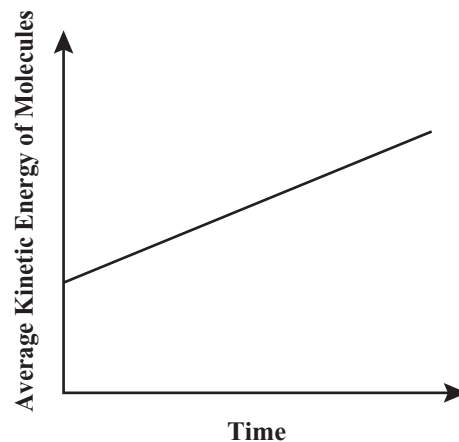
- 43 A pitcher throws a 0.15 kg baseball at 40 m/s towards the catcher. What is the momentum of the baseball while moving at 40 m/s?

A. $0.025 \text{ kg} \cdot \text{m/s}$
B. $3.8 \text{ kg} \cdot \text{m/s}$
C. $6.0 \text{ kg} \cdot \text{m/s}$
D. $270 \text{ kg} \cdot \text{m/s}$

- 44 An astronaut drops a 1.0 kg object and a 5.0 kg object on the Moon. Both objects fall a total distance of 2.0 m vertically. Which of the following **best** describes the objects after they have fallen a distance of 1.0 m?

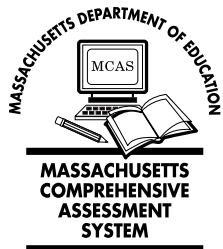
A. They have each lost kinetic energy.
B. They have each gained the same amount of potential energy.
C. They have each lost the same amount of potential energy.
D. They have each gained one-half of their maximum kinetic energy.

- 45 The graph below represents changes in molecular motion in a solid plastic cylinder over time.



These changes in the molecules of the plastic cylinder must be accompanied by which of the following?

A. an increase in mass
B. a decrease in volume
C. an increase in temperature
D. a decrease in heat capacity



Massachusetts Comprehensive Assessment System

Introductory Physics Formula Sheet

Formulas

$$\text{Average Speed} = \frac{\Delta d}{\Delta t}$$

$$\text{Average Acceleration} = \frac{\Delta v}{\Delta t}$$

$$v_f = v_i + a\Delta t$$

$$\Delta d = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$v_f^2 = v_i^2 + 2a\Delta d$$

$$F = ma$$

$$F = G \frac{m_1 m_2}{d^2}$$

$$KE = \frac{1}{2} mv^2$$

$$PE = mg\Delta h$$

$$W = F\Delta d$$

$$P = \frac{W}{\Delta t}$$

$$p = mv$$

$$V = IR$$

$$P = IV$$

$$Q = mc\Delta T$$

$$v = f\lambda \text{ and } \lambda = \frac{c}{f}$$

$$T = \frac{1}{f}$$

Variables

a = acceleration
 c = specific heat
 d = distance
 Δd = change in distance
 f = frequency
 F = force
 Δh = change in height
 I = current
 KE = kinetic energy
 λ = wavelength
 m = mass
 p = momentum
 P = power

PE = gravitational potential energy
 Q = heat
 R = resistance
 Δt = change in time
 ΔT = change in temperature
 T = period
 v = velocity
 Δv = change in velocity
 V = voltage
 W = work

Subscripts:

i = initial and f = final as subscripts

Definitions

$$G = \text{Universal gravitational constant} = 6.67 \times 10^{-11} \frac{\text{N} \cdot \text{m}^2}{\text{kg}^2}$$

$$c = \text{speed of electromagnetic waves} = 3.00 \times 10^8 \text{ m/s}$$

$$g \approx 10 \text{ m/s}^2$$

$$1 \text{ N} = \frac{1 \text{ kg} \cdot \text{m}}{\text{s}^2}$$

$$1 \text{ J} = 1 \text{ N} \cdot \text{m}$$

$$1 \text{ W} = \frac{1 \text{ J}}{\text{s}}$$

Grades 9/10 Physics
Spring 2006 Released Items:
Standards and Correct Answers

Item No.	Page No.	Standard	Correct Answer (MC)*
1	472	1.4	A
2	472	6.1	B
3	473	1.6	A
4	473	1.5	B
5	473	3.1	C
6	473	1.8	D
7	474	3.3	D
8	474	5.4	A
9	475	1.3	D
10	475	4.2	A
11	476	6.2	
12	477	5.1	D
13	477	6.1	A
14	477	2.1	B
15	478	3.1	B
16	478	3.3	A
17	478	2.4	D
18	478	4.3	C
19	479	6.2	C
20	479	2.5	B
21	479	5.4	A
22	479	1.11	C
23	480	3.1	D
24	480	2.2	D
25	481	1.7	
26	482	2.5	
27	483	6.2	A
28	483	5.1	C
29	483	1.11	A
30	484	3.1	D
31	484	2.2	C
32	485	3.1	
33	486	5.1	B
34	486	5.4	D
35	486	4.2	B
36	487	2.4	D
37	487	4.1	D
38	487	1.1	B
39	488	4.3	
40	489	3.3	C
41	489	5.4	B
42	489	4.4	A

Item No.	Page No.	Standard	Correct Answer (MC)*
43	490	2.5	C
44	490	2.2	D
45	490	3.1	C

* Answers are provided here for multiple-choice items only. Sample responses and scoring guidelines for open-response items, which are indicated by shaded cells, will be posted to the Department's Web site later this year.